Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E. SEMESTER III–EXAMINATION – WINTER 2015

Subject code: 2735005 **Date: 04/12/2015**

Subject Name: Design and Analysis of Experiments

Time: 2:30 PM to 5:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of statistical tables is permissible.**

Q.1 **(a)** What is an Experiment? Enlist various objectives of the experiment. **07**

(b) State and Explain central limit theorem. What is its importance? **07**

Q.2 **(a)** (i) What is P-value? What is its significance? **07**
(ii) Compare t-test with ANOVA.

(b) A new filtering device is installed in a chemical unit. Before its installation, a random sample yielded the following information about the percentage of impurity: $\bar{y}_1 = 12.5$, $S_1^2 = 101.17$, and $n_1 = 8$. After installation, a random sample yielded $\bar{y}_2 = 10.2$, $S_2^2 = 94.73$, $n_2 = 9$. **07**

(a) Can you conclude that the two variances are equal? Use $\alpha = 0.05$.

(b) Has the filtering device reduced the percentage of impurity significantly? Use $\alpha = 0.05$.

OR

(b) Four different feed rates were investigated in an experiment on a CNC machine producing a component part used in an aircraft auxiliary power unit. The manufacturing engineer in charge of the experiment knows that a critical part dimension of interest may be affected by the feed rate. However, prior experience has indicated that only dispersion effects are likely to be present. That is, changing the feed rate does not affect the average dimension, but it could affect dimensional variability. The engineer makes five production runs at each feed rate and obtains the standard deviation of the critical dimension (in 10^{-3} mm). The data are shown below. Assume that all runs were made in random order. **07**

Feed Rate (in/min)	Production Run				
	1	2	3	4	5
10	0.09	0.10	0.13	0.08	0.07
12	0.06	0.09	0.12	0.07	0.12
14	0.11	0.08	0.08	0.05	0.06
16	0.19	0.13	0.15	0.20	0.11

(a) Does feed rate have any effect on the standard deviation of this critical dimension? Use $\alpha = 0.05$.

Q.3 **(a)** Explain the terms Randomization and Blocking? Compare RCBD with Latin Square Design. **07**

(b) The effect of five different ingredients (A, B, C, D, E) on reaction time of a chemical process is being studied. Each batch **07**

of new material is only large enough to permit five runs to be made. Only five runs can be made in one day. Analyze the data obtain from an experiment based on Latin square as per table below. Draw your conclusions.

	Day				
Batch	1	2	3	4	5
1	$A = 8$	$B = 7$	$D = 1$	$C = 7$	$E = 3$
2	$C = 11$	$E = 2$	$A = 7$	$D = 3$	$B = 8$
3	$B = 4$	$A = 9$	$C = 10$	$E = 1$	$D = 5$
4	$D = 6$	$C = 8$	$E = 6$	$B = 6$	$A = 10$
5	$E = 4$	$D = 2$	$B = 3$	$A = 8$	$C = 8$

OR

Q.3 **(a)** Develop and explain ANOVA table Two-factor factorial design with fixed effects model. **07**

(b) Explain the importance of "Model Adequacy Checking"? Enlist various methods for Model adequacy checking for ANOVA. **07**

Q.4 **(a)** Develop Geometric view and Contrast constants table for calculating effects in the 2^3 factorial design. **07**

(b) A bacteriologist is interested in the effects of two different culture media and two different times on the growth of a particular virus. She performs six replicates of a 2^2 design, making the runs in random order as follows: **07**

	Culture Medium			
Time, h	1		2	
	21	22	25	26
12	23	28	24	25
	20	26	29	27
	37	39	31	34
18	38	38	29	33
	35	36	30	35

Estimate the factor effects. Also prepare regression model considering effect of time and interaction effect are significant.

OR

Q.4 **(a)** Derive the following relation for least squares estimator of β, **07**

$$\hat{\beta}=(X'X)^{-1}X'y$$

(b) For linear regression model, derive the equation for unbiased estimator of σ^2. Also show that $\hat{\beta}$ is unbiased estimator of β. **07**

Q.5 **(a)** Define the term "Response Surface". Explain the sequential nature of RSM to obtain optimum operating conditions. **07**

(b) The region of experimentation for three factors are time ($40 \leq T_1 \leq 80$ min), temperature ($200 \leq T_2 \leq 300^oC$), and pressure ($20 \leq P \leq 50$ psig). A first-order model in coded variables has been fit to yield data from a 23 design. The model is $\hat{y} = 30 + 5x_1 + 2.5x_2 + 3.5\,x_3$. **07**

Is the point $T_1 = 85$, $T_2 = 325$, $P = 60$ on the path of steepest ascent?

OR

Q.5 **(a)** Write a short note on "Method of Steepest Ascent". **07**

(b) Explain General 2^k Design with respect to its analysis procedure and provide general form of analysis of variance for a 2^k factorial design with *n* replicates. **07**